CHAPTER 10

STERILIZATION AND DISINFECTION

Concerns about transmitting infectious agents, such as hepatitis virus (HBV) and human immunodeficiency virus (HIV), have caused the dental community to become more aware of the need to sterilize and disinfect instruments, materials, and other equipment to protect providers and patients. In this chapter, we will explain the sterilization and disinfection process with which you, as a dental assistant, will be involved. We will also give you an overview of the procedures so you can effectively carry out your duties.

The highest level of contamination control is sterilization because it results in the total destruction of all forms of microbial life. A variety of sterilization methods and many types of liquid chemical disinfecting agents are available. Heat sterilization is preferable for all equipment and materials that can withstand high temperatures. Heat sterilization is effective, relatively easy to use, comparatively inexpensive, and readily monitored for effectiveness. Sterilization and the availability of sterile products for use in dental healthcare delivery depend on many factors. The most critical factors are as follows:

- Proper and efficient sterilization facility design
- Sound infection control practices before, during, and after sterilization
- The effectiveness of the actual sterilization process

PHYSICAL DESIGN

Dental Treatment Facilities (DTFs) must have a central sterilization room (CSR) or a central sterilization area. Centralization of sterilization activity is safer, provides more efficient use of materials and personnel, and standardizes execution and monitoring procedures. We will explain the critical design elements that make up a CSR area next.

Dedicated Work Areas

The design and outfitting of a sterilization area must include work areas for receiving, cleaning, processing, sterilizing, storing, and issuing of instruments and equipment.

Functional Flow of the Sterilization Process

Most large dental clinics will have a permanent CSR technician assigned to the sterilization area. As part of your indoctrination, you may be temporarily assigned in the CSR so you can learn your command's sterilization processes. All CSRs should have a functional flow system where equipment, instruments, and materials are first introduced into the receiving area, and work their way through to the issue area in a specific order. Figure 10-1 illustrates a CSR functional flow chart that all personnel should adhere to while working in the CSR.

Once you are physically in an area of the CSR, you must not go backwards or skip an area. This will compromise the entire sterilization process. Do not process contaminated instruments, materials, or equipment in an area that may contaminate the sterilized items.

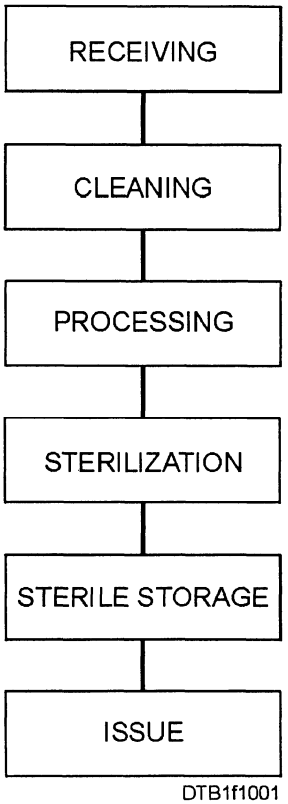

Figure 10-1.—CSR functional flow chart.

Traffic Control

Controlled access to the sterilization areas minimizes the potential for transfer of micro-organisms between contaminated items, patients, and staff. These areas must be off limits to anyone not involved in the sterilization process.

Receiving and Cleaning

Ideally, these areas will be physically separate from the remainder of the sterilization area. If physical separation is not obtainable, proper outfitting and equipment selection are critical. Commands should purchase equipment that minimizes the handling of contaminated materials and instruments. There may also be an area equipped with the utilities necessary for operating dental handpieces as shown in figure 10-2. Some commands require that the disinfection, cleaning, lubrication, and sterilization of dental handpieces take place in the CSR instead of the dental treatment room (DTR). Check to see what your command's policies are on where handpiece maintenance should take place.

Processing

A processing space should have ample work surface for the volume of materials processed. All inspecting, sorting, wrapping, and packaging of contaminated materials occur here.

Sterilization

The space requirements for the sterilization process should be determined by the available size, the degree of sufficient access for the loading and unloading, and the ability to service the sterilizer.

Sterile Storage and Issue

To protect and maintain all sterile items, the storage and issue areas should not be in the immediate vicinity of the contaminated processing areas.

THE STERILIZATION PROCESS

The sterilization process takes place in a CSR. There are many benefits to the centralized approach. Centralized instrument decontamination and sterilization are usually safer and more cost effective than instrument processing in the DTR. The

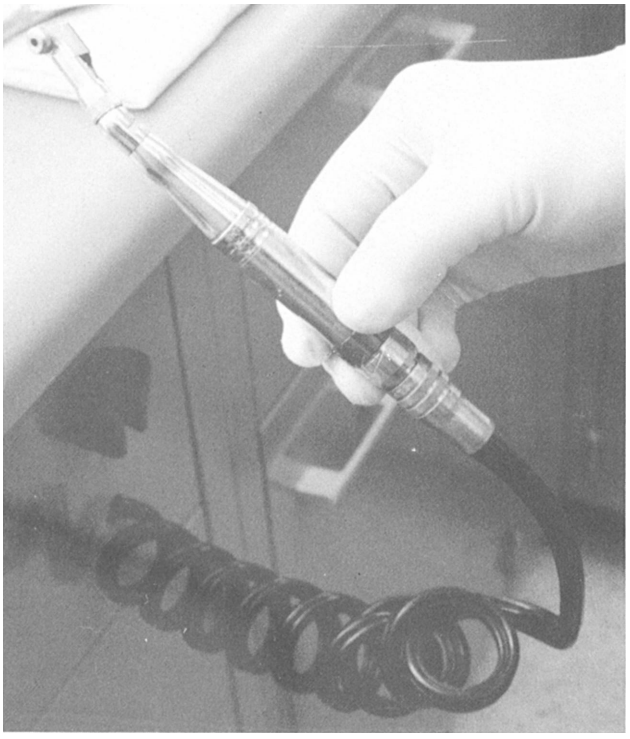

Figure 10-2.—Operating a dental handpiece in CSR.

elimination of large numbers of small capacity ultrasonic baths and tabletop sterilizers in each DTR can be replaced by the central sterilization approach that has larger capacity centralized equipment.

Whether a centralized or individual sterilization area is used, contaminated instruments and equipment must be processed as described next.

Management of Contaminated Instruments

Following the completion of a patient's treatment, the dental assistant will take the contaminated instruments and equipment directly to the CSR technician in the receiving area of the CSR. Figure 10-3 illustrates a contaminated instrument pack that has been placed in the designated drop-off location in the receiving area. The CSR technician should take the contaminated instruments and equipment and set them in the receiving area that has been designated as a temporary hold area until they can be processed.

Do not rinse, scrub, or unnecessarily handle contaminated instruments or materials in DTRs or other patient treatment areas. In the most extenuating circumstances, only the CO (designee) or the infection control officer (ICO) under written direction may make exceptions to this requirement. This does not include handpiece maintenance that will be performed in the CSR or DTR depending on your clinic's policy.

Instrument Cleaning

You should take contaminated instruments from the receiving area wearing heavy duty puncture-resistant gloves while handling all potentially contaminated items. Break down all packs and place disposable items and contaminated linens in appropriate containers. All contaminated, reusable items must be decontaminated by immersion in an Enviormental Protection Agency (EPA) registered disinfectant before further handling. This step can be eliminated if these items are cleaned in an ultrasonic cleaner (bath) with an EPA-registered disinfectant that also is approved as an ultrasonic cleaning solution. Process instruments using one of the following methods. They are discussed in order of preference.

AUTOMATED WASHER PROCESSOR.— The automated washer processor is the safest method and provides an effective cleaning process. It is commonly used in hospitals or very large dental clinics. Contaminated instruments are placed in cassettes or baskets. Then they are run through the unit's cycle of cleaning, rinsing, and disinfection at temperatures high enough to provide at least a high level of disinfection. This results in a "not touch" system in which the potential for injury during instrument processing is greatly reduced.

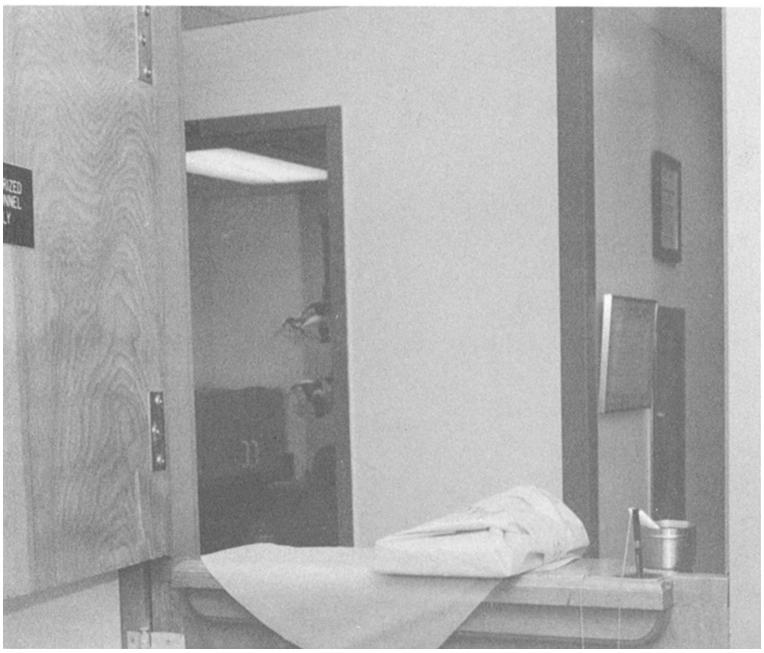

Figure 10-3.—Contaminated instrument pack placed at the entrance of the receiving area in the CSR.

ULTRASONIC CLEANING.—This process is safer and more effective than manual scrubbing. The ultrasonic cleaner eliminates the possibility of accidental puncture wounds on the hands that frequently occur with manual scrubbing. It also eliminates the splatter of organism-laden debris generated by scrubbing with a brush. The ultrasonic cleaner uses electrical energy to generate sound waves. When the sound waves travel through the liquid, millions of tiny bubbles form and burst continuously. This process is called a *"cavitation"* effect. The bursting bubbles scrub everywhere the liquid can penetrate. Intricate surfaces and difficult access areas, such as burs, endodontic files, serrated instrument handles, and hinged instruments, are cleaned more thoroughly and rapidly. The usage life of cutting instruments, such as burs and endodontic files, is extended by thoroughly removing debris that interferes with the cutting surfaces.

There are several sizes of ultrasonic cleaning units. Figure 10-4 illustrates small and large size ultrasonic cleaners. The ultrasonic cleaner should be located in the processing area of the CSR. The manufacturer's instructions must be followed when using ultrasonic cleaners. These instructions should be posted or readily available in locations where the units are used.

The following general guidelines are common to the proper use of all ultrasonic cleaners:

- Always keep the ultrasonic cleaner reservoir 1/2 to 3/4's full with ultrasonic solution at all times.
- The solution must completely cover the items for the ultrasonic action to occur.
- Avoid the use of disinfectants, plain water, and nonultrasonic soaps or detergents.
- Cleaning solutions must be changed at least daily or sooner, if visibly contaminated.

When using the ultrasonic cleaner follow these guidelines

- Place instruments into a perforated or wire mesh basket and rinse under water first.
- Place basket holding the instruments into the ultrasonic cleaner unit filled with solution.
- Never place items directly on the bottom of tanks. This would reduce the amount of ultrasonic waves produced and could damage the unit.
- Always close the lid or cover on the unit when in use to decrease aerosols and avoid splattering of the solution onto adjacent surfaces.
- Limit ultrasonic cleaning time to 5 minutes to avoid damage to instruments. Follow manufacturer's instructions for exact cleaning times for different models.
- Longer cleaning times may be required for some nonmetallic instrument cassettes.

Never use your hand to remove instruments from the unit. Instead, use the basket to lift the instruments from the solution, drain, and rinse them under running water. Be sure to rinse the instruments thoroughly to remove all the remaining solution. Inspect the instruments for remaining blood or debris, then dry thoroughly.

MANUAL SCRUBBING.—Although manual scrubbing is time consuming and presents an increased potential for contamination injury, this method is effective for cleaning instruments when automated washer processors or ultrasonic cleaning units are not available. Triple-sink modules allow personnel to perform in an orderly sequence multiple functions such as prerinsing, soaking, washing, and final rinsing. While wearing heavy-duty utility gloves, face mask, plastic apron, and eye protection, place instruments in

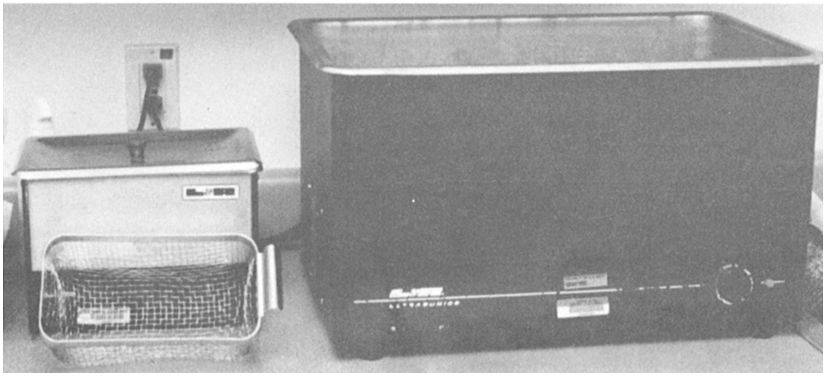

Figure 10-4.—Small and large size ultrasonic cleaners.

a disinfecting solution, allow them to soak, and then scrub them under water to avoid generating splatter.

PRESTERILIZATION PROCESSING

You are still in the processing area of the CSR and have just finished cleaning your instruments using one of the three methods of cleaning discussed previously and letting them dry as shown in figure 10-5. Perform the following procedures in the sterilization process next.

Inspection and Sorting of Instruments

After drying, you must inspect items closely for wear, breakage, and cleanliness. Sort instruments according to sets or packs. This is the prestaging area where your instruments are sorted before wrapping and packaging.

Wrapping and Packaging

Wrapping and packaging is the last step just before the sterilization process. Many different types of sterilizers, packaging, and wrapping materials are used in the CSR.

Before terminal (final) sterilization, wrap or package all critical and semicritical items individually or in sets. Ensure you place consumable supplies (fig. 10-6) that are required by your command in each particular pack before wrapping such items as needles, cotton rolls and pellets, gauze, aluminum foil for dental light handles, internal indicators, and towels.

Dental instruments are usually placed in packs, on trays or cassettes, before placing them into the sterilizer. The most common wrapping materials and containers are paper, paper/plastic, nylon tubing, and cloth. Aluminum foil, closed metal trays, and perforated cassettes may also be used. The packaging or wrapping materials that you select depends on the compatibility of what type of sterilization method you are using. Table 10-1 shows various sterilization packaging materials and their suitability to withstand steam or dry heat sterilization. Always refer to the sterilizer manufacturer's instructions for suitability.

Paper materials are available in the form of bags or flat disposable wraps. Both types are sealed with adhesive indicator tape. The combination paper/plastic peel packs (fig. 10-7) are available in varied sizes of preformed bags or rolls of varied widths that can be cut to the desired length. Either type can be sealed with the adhesive indicator tape or self-sealed.

Heat sealed plastic or nylon tubing should only be used as an overwrap after the pack has been sterilized. Heat sealed overwrapping will extend a 30 day shelf life to 180 days.

Figure 10-5.—Instruments drying in the processing area.

Figure 10-6.—Consumable supplies.

Table 10-1.—Sterilization Packaging Materials and Suitability for Steam or Dry Heat Sterilization

MATERIAL	NATURE	THICKNESS OR GRADE	SUITABLE FOR STEAM	SUITABLE FOR DRY HEAT
Muslin	Textile	140 count	Yes	Yes
Jean cloth	Textile	160 count	Yes	No
Broadcloth	Textile	200 count	Yes	No
Kraft brown	Paper	30-40 lb.	Yes	No
Kraft white	Paper	30-40 lb.	Yes	No
Glassine	Coated paper	30 lb.	Yes	No
Parchment	Paper	Patapar 27-2T	Yes	No
Crepe	Paper	Dennison wrap	Yes	No
Cellophane	Cellulose film	Week sterilizable	Yes	No
Polyethylene	Plastic	1-3 mils	No	No
Polypropylene	Plastic	1-3 mils	No*	No
Polyvinyl	Plastic	1-3 mils	No	No
Nylon	Plastic	1-2 mils	No*	No
Polyamide	Plastic	1-2 mils	No*	No
Aluminum	Foil	1-2 mils	No	Yes
Peel packs	Paper with plastic		Yes	No
Test tubes	Glass with heat resistant caps		No	Yes

*Specifically not recommended due to difficulty in eliminating air from packs.

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The practical use of some semicritical items may preclude wrapping or packing. Basic guidance in proper wrapping techniques includes the following:

- Using trays or cassettes to reduce the possibility of puncturing the wrapping material and risk of injury during post-treatment handling.
- Wrapping loosely to allow steam to circulate freely throughout the pack. Arrange items so that all surfaces receive direct exposure to the sterilization agent.
- Opening all hinged instruments during packaging to allow steam to penetrate these areas.

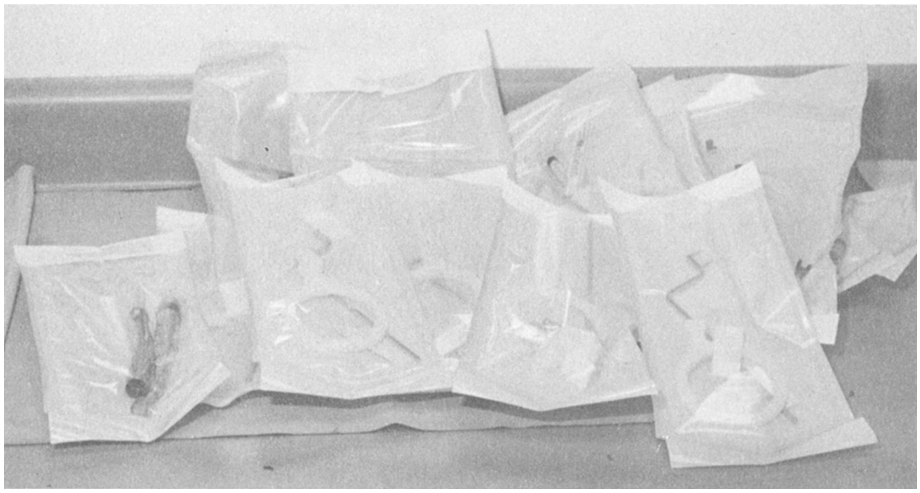

Figure 10-7.—Paper/plastic peel packs.

Using proper wrapping material for instrument sets. The use of muslin wraps are discouraged.

Cloth and nonwoven wraps are sealed with external indicator tape as illustrated in figure 10-8. The indicator tape will change color if exposed to the sterilization elements.

When wrapping instrument packs with indicator tape, always turn the tabs down on the tape. This provides a folded edge to aid in opening the package and removing the tape.

Launder muslin towels after each use and inspect for tears or pinholes.

Follow the manufacturer's time and temperature settings on sterilizers for the types of wrapping material used.

Using internal and external chemical indicators or multi-parameter integrators (measures temperature, steam and time).

Expiration Dates

After the packs, instruments, and supplies are wrapped or placed into containers and sealed, they must be labeled with the identification number of the sterilizer, the preparer's initials, and the dates of sterilization and expiration before they are placed in the sterilizer. To label, use an ink marker, preprinted indicator tape, or a marking device that won't run or fade when exposed to sterilization.

The shelf life or expiration date of sterilized items is the period during which an item is considered safe for use. Shelf life can be **time-related** or **event-related.** Your command ICO will determine what method your sterilization program will use.

TIME-RELATED.—Time-related shelf life is identified with an exact expiration date. After this date, the item is considered to be outdated and should not be used. Table 10-2 lists the different wrapping methods and their time-related shelf life in accordance with BUMEDINST 6600.10.

EVENT-RELATED SHELF LIFE.—The use of the event-related method presumes continued sterility until the package is damaged, wet, or torn. It is a well-recognized standard for items in good quality, self-sealed or hermetically (airtight) sealed, packaged in paper or plastic, or sequentially-wrapped and sealed

Table 10-2.—Time-Related Shelf Life of Sterilized Items

WRAPPING METHOD	TIME-RELATED SHELF LIFE
Paper envelope (sealed with sterilization tape)	365 days
Nonwoven blue wrap	30 days
Nonwoven blue wrap, plastic covered, heat-sealed	365 days
Peel plastic packs, heat-sealed or self-sealed	365 days
Parchment paper or Dennison wrap	30 days
Glass test tubes with screw caps	indefinite

Figure 10-8.—Cloth and nonwoven wraps with external indicator tape.

in dust covers within a few hours after sterilization. If this method is used, the command policy must be clearly defined and consistently used throughout the DTF. When using the event-related method, all sterilizers must be biologically monitored at least weekly.

Sterile Storage

Sterility of dental materials, instruments, and supplies is much harder to maintain than it is to achieve. There is little value in precise sterilization procedures if instruments are contaminated upon completion of the process. Items must be dry before they are handled or stored. The time required for drying depends on the type of packs in the load and the sterilizing agent used. Freshly sterilized items are never placed on metal or cold surfaces. Packages become damp from the condensation that occurs and become contaminated.

All sterile supplies, including sterile reusable dental items, must be stored in a manner that will preserve their sterility until used. The following factors affect this process:

- Environmental conditions including cleanliness? proper ventilation, and control of excess heat and humidity are important.

- The location where sterile supplies are stored should not be in a manner that may contribute to the increased possibility of contamination. Figure 10-9 shows an acceptable sterile storage cabinet containing sterilized packs and instruments.

- Sterile items should not be stored in patient treatment or decontamination areas unless they are protected by enclosures, such as drawers or cabinets.

- Sterile and clean patient treatment items may be stored in the same drawers or cabinets, as long as there is no possibility of nonsterile items being used inadvertently when sterility is required.

- Sterile items should not be stored with items not intended for clinical use (e.g., office and cleaning supplies).

- Items must not be stored on the deck, under sinks, in window sills, adjacent to heating and air conditioning vents, or in any area where undetected contamination may occur.

When storing sterilized items, arrange them according to expiration date, placing items with later dates toward the rear. Check supplies periodically to determine any need for resterilizing. Items must be resterilized if the wrapper becomes wet, if the pack touches the deck, if there is any question of contamination, or if the safe storage period has expired.

STERILIZATION METHODS

Because of the composition of many of the items used in dentistry, no single sterilization method is

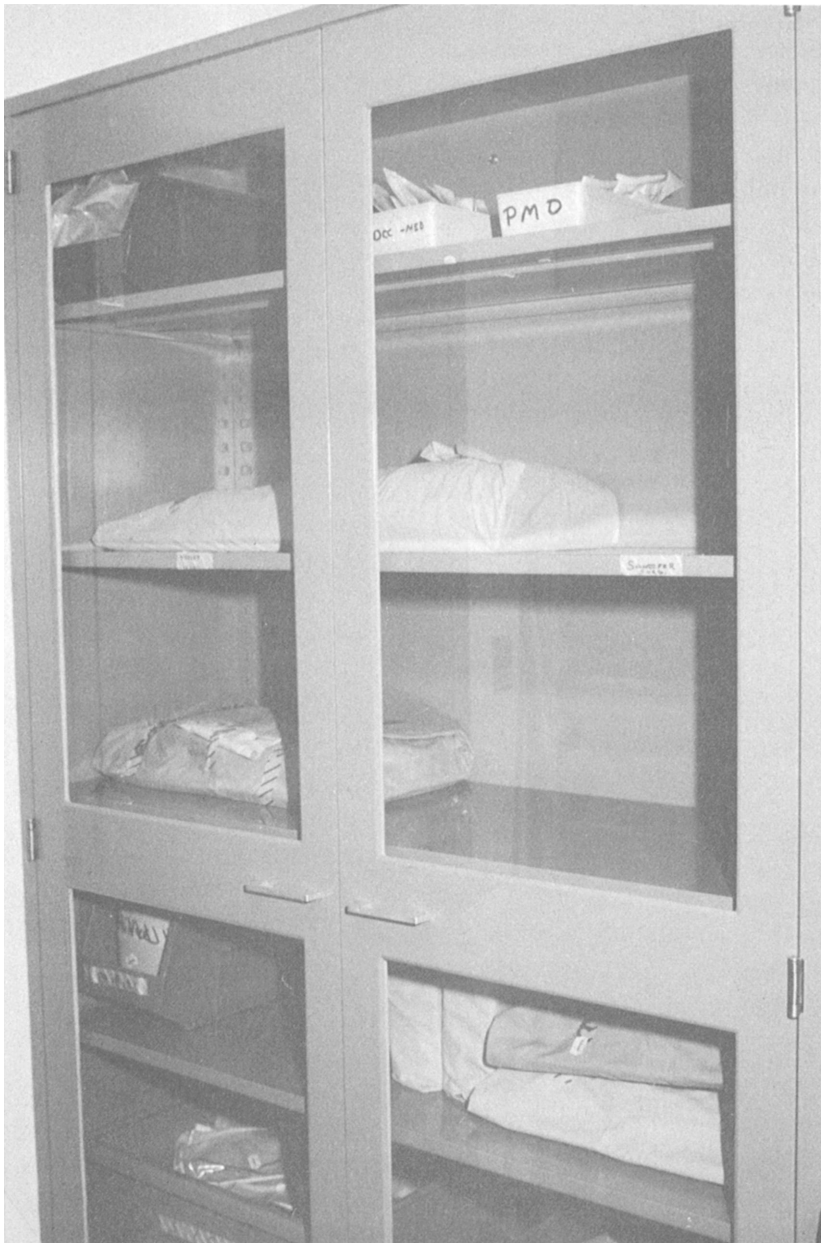

Figure 10-9.—Sterile storage cabinet.

suitable for all dental items. As a basic dental assistant, you will need to know several approved methods of sterilization.

Steam Heat Sterilization

Steam under pressure (saturated steam) is the most effective means of sterilization for almost all items used in dentistry. To achieve sterility, moist heat under pressure must come in contact with all surfaces of all items for the appropriate length of time. To effectively sterilize items using saturated steam, the temperature of the steam throughout the load must be high enough to destroy the most resistant micro-organisms in the time allotted for sterilization. For example, some spores can withstand temperatures above the normal boiling point of water (212°F or 100°C); so the relationship of temperature to spore killing power is critical. Steam temperature and exposure time, not pressure, are crucial components of this process. Pressure is used only to raise the temperature of the steam and, in itself, has nothing to do with microbial killing action. At 15 pounds per square inch (psi), the boiling point increases to 121°C (250°F), a temperature at which all known organisms are killed.

In addition to the high temperature, steam must be saturated so that it will quickly release heat through condensation when it comes into contact with a cool object. Sterilization will not occur unless all air is eliminated from the chamber at the beginning of the process and periodically throughout sterilization. The packaging of supplies and loading of the sterilizer must be done so that steam comes in contact with all areas or surfaces of the items being sterilized.

Flash sterilization is defined as the sterilization of unwrapped items in a gravity displacement or prevacuum sterilizer with recommended minimum exposure times and temperatures. Steam sterilization by this unwrapped method is not recommended. It should be used only for emergency sterilization.

Types of Steam Sterilizers

A steam sterilizer, also know as an "autoclave," is a pressure-type vessel with a door or cover, valves to control the entry and exit of steam and air, and monitoring devices to allow the operator to observe conditions inside. It is designed to hold items and allow steam under pressure to penetrate these items. Steam sterilizers are available in many sizes, ranging from portable countertop to the fixed room-size sterilizer. Two of the most common types of steam sterilizers used in the Navy are the gravity displacement and prevacuum sterilizers.

GRAVITY DISPLACEMENT.—Once this sterilizer is loaded and the door is closed as shown in figure 10-10, steam is admitted through an inlet and the sterilization process begins. A typical standard for steam sterilization is achieved at 250°F or 121°C after 20 to 30 minutes at 15 psi. It is important to refer to the manufacturer's instructions for operation, since exposure times can vary according to the design of the particular sterilizer.

You should observe the following precautions when loading the sterilizer chamber:

- **Do not overload.** The passage of steam from the top of the chamber to the bottom should not be blocked.
- Place all packages on edges, with large packs at the bottom of the chamber, and small packages in an upper layer crosswise to the lower layer. This allows free passage of steam.
- If mixed loads of metal items and linen are sterilized together, the linen is placed on the upper shelf and the metal items on the lower.
- Articles that require the same amount of time and the same final steps should be sterilized together.
- Enclosed fluids are sterilized separately because the pressure must be slowly released.
- Load all packages at the same time when you are ready to sterilize.

A standard operation chart for the correct exposure period of all supplies should be prepared and posted for easy daily reference. It is important to note that sterilizing conditions are based on temperature rather than on pressure. Effective steam sterilization and exposure time are measured from the moment the thermometer in the discharge line indicates the desired preset temperature. The pressure inside the sterilizer is not an indication of positive sterilization because other factors determine the pressure inside the sterilizer. Pressure merely maintains temperature.

PREVACUUM STEAM STERILIZER.—The prevacuum steam sterilizer (fig. 10-11) was designed to help overcome the trapping of air in the chamber. Trapping of air is one of the greatest dangers encountered when using saturated steam under gravity cycles. When errors are made by improperly packaging items or overloading the sterilizer chamber, cool air pockets may form resulting in items not being sterilized. The speed and efficiency of the steam sterilizer may be improved by removing air from the chamber with a powerful pump, creating a nearly perfect vacuum before steam is introduced into the chamber. This procedure allows fast and more positive heat to penetrate the entire sterilizer load. The improved sterilizer is referred to as the prevacuum steam sterilizer.

Full heating of the loads is faster in the prevacuum sterilizer than in the gravity displacement sterilizer. For example, wrapped instruments can be sterilized at 270°F (131°C) after 4 minutes exposure in a prevacuum steam sterilizer. Consult the manufacturer's instructions for specific details on operation and user maintenance information.

The **Bowie-Dick** type test was developed for prevacuum sterilizers to determine if the air has been removed from the chamber during the prevacuum stage. Air must be removed so that steam can penetrate the load instantaneously. It must be understood that this is not a test for adequate exposure to heat in terms of time-at-temperature. A commercially prepared Bowie-Dick type test can be used by carefully reading and following the manufacturer's instructions. All

Figure 10-10.—Gravity displacement steam sterilizer.

Navy prevacuum sterilizers will be tested daily using the Bowie-Dick type test.

Level One Maintenance

The interior of the steam sterilizer should be cleaned each day before being heated. This simple procedure can easily be accomplished by using a mild detergent to wash the surfaces. Follow the wash with a thorough rinse of plain water. Unless this is done, the chamber walls will collect mineral deposits and may become greasy. Do not use wire brushes, steel wool, or any type of abrasive cleaning compounds on the sterilizer. The manufacturer's directions must be followed to maintain a properly functioning sterilizer. If the sterilizer does not appear to function properly, dental equipment repair personnel should check it at once. Sterilizers should be spot checked frequently for leaks in lines and improperly functioning gauges, dials, thermometers, doors, drain strainers, and valves.

Dry Heat Sterilization

The least expensive form of heat sterilization of instruments is dry heat. Destruction of micro-organisms by dry heat in a DTF is accomplished by using a unit that has been tested and approved by the FDA as a commercial sterilizer.

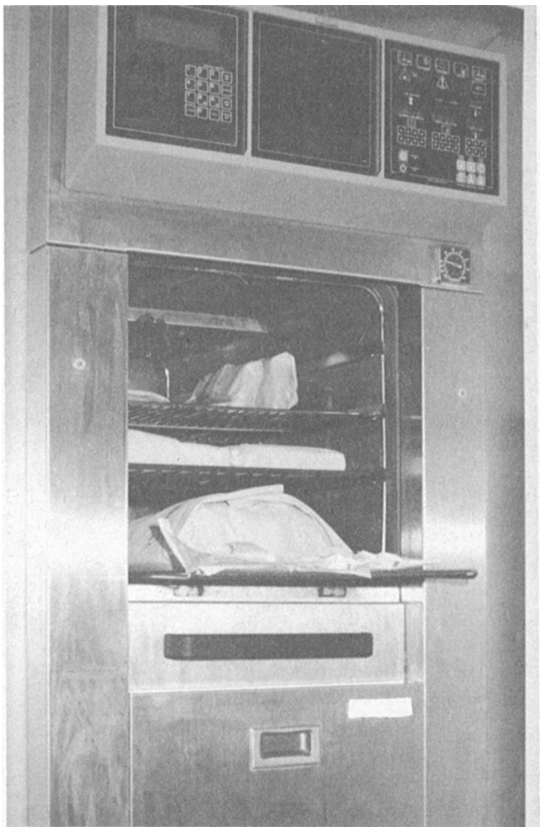

Figure 10-11.—Prevacuum steam sterilizer.

Dry heat is suitable for sterilizing metal instruments that rust or dull in the presence of water vapor. A disadvantage is that the high temperatures destroy many rubber and plastic based materials, melt the solder of most metal impression trays, and weaken some fabrics, as well as discolor other fabrics and paper materials.

A complete cycle involves heating the dry heat oven (fig. 10-12) to the appropriate temperature and maintaining that temperature for the proper time interval. Depending on the location, dry heat ovens can use one of the following heating elements to achieve sterilization:

- Conduction (direct contact with a heat source)
- Radiation (long electromagnetic waves)
- Convection (heated air)

Because dry air is not as efficient a heat conductor as moist heat at the same temperature, a much higher temperature is required for sterilization. One of the most common problems with the use of dry heat sterilization is the failure to properly time the exposure. A typical dry heat cycle is 90 minutes at 320-345°F, plus the time required to preheat the chamber before beginning the sterilization cycle. A common misuse of the dry heat method occurs when the oven door is opened, and an instrument is quickly removed during the timed cycle. This interrupts the cycle and timing must begin all over again.

Advances in the design of the dry heat oven resulted in the development of the dry heat convection unit, which uses forced air at higher temperatures. This method of rapid heat transfer achieves sterilization in 12 minutes at 375°F (190°C) for wrapped items and in 6 minutes for unwrapped items. Biological monitoring will be performed weekly. Consult the manufacturer's instructions of each type of dry heat sterilizer for specific details on its operation and user maintenance.

Chemical Vapor Sterilization

This process uses a mixture of chemicals, including alcohol, formaldehyde, ketone, acetone, and water, that are heated under pressure to form a sterilizing gas. Sterilization requires 20 minutes at 270°F with 20 psi when instruments are either unwrapped or bagged following the manufacturer's instructions.

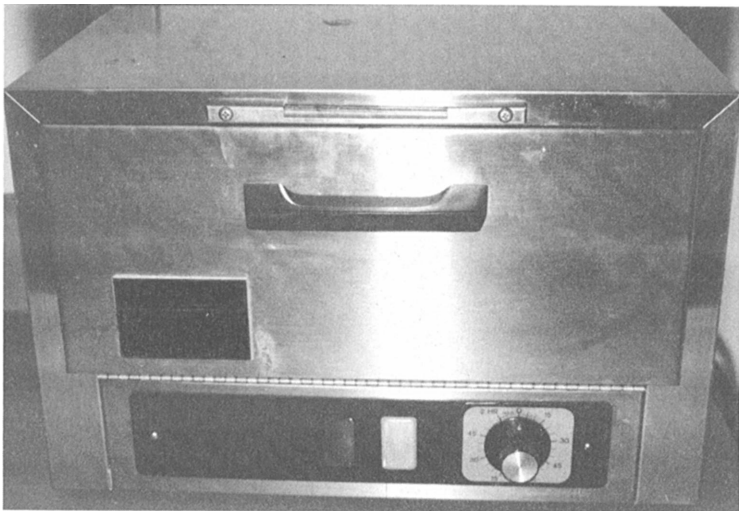

Figure 10-12.—Dry heat sterilizer.

Advantages to chemical vapor sterilization are as follows:

- No corrosion, rusting, and dulling of instruments since water content is only 15 percent (if instruments are dry when placed in chamber).
- Prevents destruction of dental items, such as endodontic files, orthodontic pliers, wires and bands, burs, and carbon steel instruments.
- Instruments are dry at the end of the cycle.

The major disadvantage of this sterilization method is the requirement for adequate ventilation. Chemical vapors, particularly formaldehyde, can be released when the chamber door is opened, leaving a temporary but unpleasant odor in the area.

Chemical vapor sterilization is not routinely used in Navy dentistry. Consult the manufacturer's instructions for specific details on operation and required user maintenance.

Ethylene Oxide Sterilization

Ethylene oxide (ETO) gas uses relatively low temperatures for sterilization. Using a heated unit, sterilization can be achieved in 2-3 hours at 120°F. However, a lengthy aeration time must follow each cycle.

Materials such as suction tubing, handpieces, radiographic film holders, and prosthetic appliances may be sterilized without adverse effects. Follow the manufacturer's instructions for safety precautions, operation, and maintenance. Because of the serious Occupation Safety Health Agency (OSHA) problems with ETO gas, COs of Naval Dental Clinics (NDCs) should not purchase new ETO equipment. Large naval hospitals with ETO capabilities in their CSR may use them to sterilize nonheat stable dental instruments and equipment.

Liquid Chemical Sterilization

The Food and Drug Administration (FDA) classifies chemical disinfectants that are sporicidal as disinfectants, the FDA classifies all sterilants. Since monitoring the liquid sterilization process is virtually impossible, treat these products as high-level disinfectants rather than sterilants. Be sure to follow the manufacturer's directions exactly.

Bead and Salt Sterilizers

Use bead and salt sterilizers only during the endodontic procedure for sterilization of clean metallic instruments. Do not use them to sterilize instruments between patients. Clean contaminated instruments with an alcohol saturated gauze to remove blood and debris before inserting into the bead and salt

sterilizers. Monitor and record at least weekly the temperature in the sterilizer well. If using salt in place of beads in the sterilizer, line the well with aluminum foil to prevent corrosion.

CRITICAL CATEGORY ITEMS REQUIRING STERILIZATION

All critical category items require sterilization. Table 10-3 lists a variety of different dental instruments and materials and shows what type of sterilization or disinfection is effective and preferred for each particular item. It also lists methods that are effective and acceptable, effective but risk damage, and ineffective with risk of damage to materials. Sterilize critical category items before turning them in for service or repair.

Following BUMEDINST 6600.10, sterilize critical category items as follows:

Surgical instruments—Effective and preferred methods of sterilization are the steam autoclave, dry heat oven, chemical vapor, or ethylene oxide.

Handpieces—Handpieces include: low-speed motor attachments, sonic scaler, and tips. Follow manufacturer's instructions. See table 10-3, for recommended method of sterilization. Follow manufacturer's instructions for the cleaning of the fiber optic bundle.

Burs and diamonds—Clean burs and diamonds and dry before sterilizing. Many burs and diamonds are used only for single patient use. One accepted method of sterilization for burs and diamonds are to place them in a screw cap glass test tube (fig. 10-13) or an aluminum foil wrapped bur block and dry heat sterilize for 90 minutes at 320-345°F. Place a chemical indicator in each tube or wrapped bur block. At least weekly, place a biological monitor in one tube or foil wrapped block during the first load of the day,. retrieve and send for culture testing following the manufacturer's recommendations.

Endodontic files and Gates-Glidden burs—Arrange sets in file blocks and seal in peel packs before autoclaving. When additional files or burs are necessary, take them from a new package or from a file storage box and sterilize them in a bead or salt sterilizer before use. Use endodontic broaches once and discard into a sharps container. *Dental Technician, Volume 2,* NAVEDTRA 12573, chapter 7, illustrates and explains endodontic broaches.

STERILIZATION MONITORING

Any number of factors can reduce the effectiveness of sterilizers. Overloading and improper wrapping can prevent adequate penetration into the instrument surface. Improper timing, temperature variations, worn gaskets and seals, and sterilizer malfunctions can prevent sterilization. Heat sterilization methods are generally reliable and effective. Nevertheless, regular monitoring of sterilization cycles is necessary to detect inadequate process conditions caused by human error or equipment malfunction.

Types of Sterilization Monitors

Commands should base selection of sterilization monitors on reliability, appropriateness to the process, safety, and cost effectiveness. Many types of monitors are available. The three most commonly used sterilization monitors in the Navy DTFs are biological monitors, internal indicators, and external indicators.

BIOLOGICAL MONITORS.—Biological monitors are designed to assess whether sterilization actually occurred. These systems consist of bacterial endospores impregnated in paper strips or sealed in glass ampules or plastic vials.

INTERNAL INDICATORS.—Internal indicators are chemical dyes that change color when exposed to steam, dry heat, or chemical vapor for a specified period of time. When placed inside an instrument pack, they determine whether the conditions necessary for sterilization have been met.

EXTERNAL INDICATORS.—External indicators are chemical dyes that change color upon short exposure to sterilizing conditions. They are generally printed on packaging materials or supplied in tape form and are necessary to distinguish processed packages from those that have not been cycled. External indicators are not sensitive enough to be processed as an internal indicator and should not be used.

Biological Monitoring

After endospore tests are processed through a sterilization cycle, they must be incubated according to the manufacturer's instructions. A pH indicator in the medium changes color when the ampule of endospores germinate and produce acids. This visually identifies a failure in the sterilization process. As a minimum,

Table 10-3.—Sterilization and Disinfection of Dental Instruments and Materials

	Steam Autoclave	Dry Heat Oven	Chemical Vapor	Ethylene Oxide	Chemical Disinfection	Other Methods / Comments
Angle attachments*	+	+	+	++	+	
Burs						
Carbon steel	—	++	++	++	—	
Steel	+	++	++	++	+	
Tungsten-carbide	+	++	+	++	+	
Condensers	++	++	++	++	+	
Dappen dishes	++	+	+	++	+	
Endodontic instruments (broaches, files, reamers)						Hot salt or glass bead sterilizer for 10 - 20 seconds at 218°C (425°F)
Stainless steel handles	+	++	++	++	+	
Stainless with plastic handles	++	++	—	++	—	
Fluoride gel trays						
Heat-resistant plastic	++	— —	—	++	—	
Non-heat resistant plastic	— —	— —	—	++	—	Discard (++)
Glass slabs	++	++	++	++	+	
Hand instruments						
Carbon steel	—	++	++	++	—	
	Steam autoclave with chemical protection (1% sodium nitrite)					
Stainless steel	++	++	++	++	+	
Handpieces*						Autoclavable preferably
Autoclavable*	(++)*	—	(+)*	++	— —	
Contra-angles*	—	—	—	++	+	Combination synthetic phenolics or iodophors (—)
Nonautoclavable*	—	—	—	++	+	
Prophylaxis angles*	+	+	+	+	+	
Impression trays						
Aluminum metal	++	+	++	++	—	
Chrome-plated	++	++	++	++	+	
Custom acrylic resin	— —	— —	— —	++	+	
Plastic	— —	— —	— —	++	+	Discard (++), preferred
Instruments in packs	++	+ Small packs	++	++ Small packs	— —	
Instrument tray setups						
Restorative or surgical	+ Size limit	+	+ Size limit	++ Size limit	— —	
Mirrors	—	++	++	++	+	
Needles						
Disposable	— —	— —	— —	— —	— —	Discard (++), Do not reuse
Nitrous oxide						
Nose piece	(++)*	— —	(++)*	++	(+)*	
Hoses	(++)*	— —	(++)*	++	(+)*	
Orthodontic pliers						
High quality stainless	++	++	++	++	+	
Low quality stainless	—	++	++	++	—	
With plastic parts	— —	— —	— —	++	+	
Pluggers	++	++	++	++	+	
Polishing wheels and disks						
Garnet and cuttle	— —	—	—	++	— —	
Rag	++	—	+	++	— —	
Rubber	+	—	—	++	+	
Prostheses, removable	—	—	—	+	+	
Rubber dam equipment						
Carbon steel clamps	—	++	++	++	—	
Metal frames	++	++	++	++	+	
Plastic frames	—	—	—	++	+	
Punches	—	++	++	++	+	
Stainless steel clamps	++	++	++	++	+	
Rubber items						
Prophylaxis cups	—	—	—	++	—	Discard (++)
Saliva evacuators, ejectors						
Low melting plastic	—	—	—	++	+	Discard (++)
High melting plastic	++	+	+	++	+	
Stones						
Diamond	+	++	++	++	+	
Polishing	++	+	++	++	—	
Sharpening	++	++	++	—		
Surgical instruments						
Stainless steel	++	++	++	++	+	
Ultrasonic scaling tips	+	— —	— —	++	+	
Water-air syringe tips	++	++	++	++	+	
X-ray equipment						
Plastic film holders	(++)*	— —	(+)*	++	+	
Collimating	—	— —	— —	++	+	

The table is adapted from Accepted Dental Therapeutics and Dentist's Desk Reference: Materials, Instruments and Equipment.

* As manufacturers use a variety of alloys and materials in these products, confirmation with the equipment manufacturers is recommended, especially for handpieces and attachments.

++ Effective and preferred method.

\+ Effective and acceptable method.

— Effective method, but risk of damage to materials.

— — Ineffective method with risk of damage to materials.

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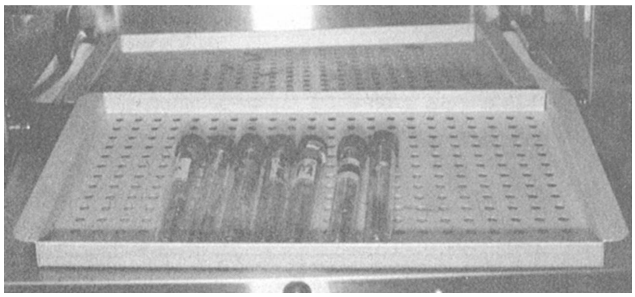

Figure 10-13.—Burs in glass test tubes.

perform biological monitoring weekly. Figure 10-14 shows a biological incubator with endospore tests.

TEST PROCEDURE.—Since biological monitoring systems are designed for specific sterilization methods, you must be sure to use a system compatible with the sterilization method used. The following test procedures should be used to ensure effectiveness of the sterilization process:

- The use of a "test pack" is most practical while processing an instrument pack.
- Biological spore strips or ampules should be placed between several layers of folded wrapping material, and then the test pack is double-wrapped in the normal manner.
- Always follow the biological monitor manufacturer's directions for the placement of the test pack within the sterilizer.
- As a general rule, the biological spore strips or ampules should be placed within an area of the sterilizer that is least accessible to the sterilizing agent that is being used.
- If using steam under pressure sterilizers, place the test pack in the lower front of the sterilization chamber.
- If using tabletop units, place the test pack in the center of the load.
- For each test, use an unprocessed monitor for a control.

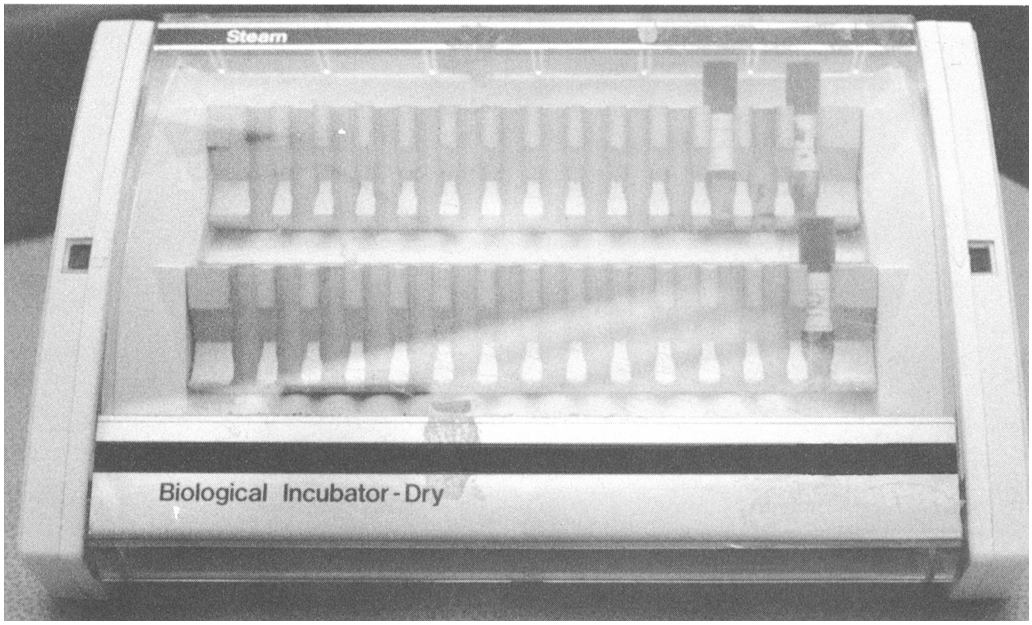

Figure 10-14.—Biological incubator.

EVALUATION CRITERIA.—After the completion of the sterilization cycle, open the test pack and evaluate the dosage indicator to see if it passes or fails the cycle. If it passes, you can distribute the sterile goods and continue the biological test procedure. If it fails, follow the procedures under guidelines for internal and external indicators.

POSITIVE RESULTS.—When positive biological monitoring occurs, you must follow these guidelines:

- Notify the ICO and record the test results in the sterilization log.
- If another sterilizer is available, perform the following actions:

— Retrieve and resterilize all items sterilized since the last negative test of that sterilizer tested positive.

— Process a test pack with both a chemical and biological monitor and secure the sterilizer from further use until the results of the biological and chemical tests are read.

— If the results of the biological and chemical tests indicate negative growth or pass the sterilization test, the sterilizer can be placed into service.

— If the results from the test still indicate positive growth or failure of sterilization, the sterilizer must be secured and dental repair personnel notified.

- If another sterilizer is not available, perform the following actions:

— Notify dental repair personnel.

— Retrieve and resterilize all items processed since the last negative test. Use a test pack with a biological and chemical monitor in each load when resterilizing all items that came up positive from the last test.

— If a chemical monitor in the test pack indicates a pass of the sterilization test, these loads can be distributed if necessary. The ideal situation is to have adequate instruments and equipment to be able to hold these items for 48 hours after a negative biological test and then distribute.

— If the biological test again fails, secure the sterilizer and notify dental repair personnel, and the ICO.

- Make a narrative entry in the log of each action taken and the results as they occur.
- Retest the sterilizer using biological monitors.
- Confirm exposure of the biological monitor to sterilization process.
- Review the sterilization log for recent repairs or maintenance.

GUIDELINES FOR INTERNAL AND EXTERNAL INDICATORS.—Use internal indicators inside and external indicators on the outside of each instrument pack. When using glass test tubes during dry heat sterilization, ensure an internal indicator is in each test tube before the screw top is secured. When any indicator of a load test pack fails, resterilize it with a new test pack containing both chemical and biological monitors. Be sure to closely monitor the temperature, pressure, and sterilizing time of the load. Watch the timer to be sure it does not start before the correct temperature is reached. Watch for steam leaks from the sterilizer during the sterilization cycle. If the indicator again fails, notify the ICO and dental repair personnel. Log in the results from the failure, and secure the sterilizer from use until the results of the biological monitor can be evaluated.

Follow the manufacturer's instructions when reading the indicators. Please be aware that internal and external indicators are not replacements for biological monitoring. Only biological monitoring can tell you whether or not sterilization has actually occurred.

LIQUID STERILANTS.—Since liquid sterilants cannot be biologically monitored, their use is discouraged. In using these agents, the key is the time that instruments and equipment are in contact with the sterilizing agents. Test strips for concentration levels must be used according to manufacturer's instructions.

DISINFECTION

Disinfection is a less lethal process than sterilization, which kills disease causing micro-organisms. This does not include the destruction of resistant bacterial spores. Disinfection is achieved by either chemical or heat means. Selecting an appropriate chemical germicide or heat disinfection method depends on what requirements need to be met

for that particular product. The following are some of the criteria for effective chemical disinfection:

- The degree of microbial kill or deactivation required
- The composition and texture of the item being treated
- The technical requirement and ease of use of the available agents

Regardless of the product selected, there is no single chemical or heat agent available today that will meet all these criteria. As always, follow label directions precisely. Give strict attention to the proper use of the product regarding mixing, dilution, method and duration of the application, temperature requirements, shelf-life, and if applicable, reuse life.

LEVELS OF DISINFECTION

The EPA classifies disinfectants as high, intermediate, or low level, based on the effectiveness and contact time of the solution and the biocidal activity of an agent against bacterial spores, mycobacterium tuberculosis, lipid and nonlipid viruses, and vegetative bacteria. Table 10-4 describes the level of disinfection required to kill the micro-organism named.

FACTORS INFLUENCING GERMICIDAL PROCEDURES

The factors associated with the micro-organisms, as well as those associated with the surrounding physical and chemical environment, influence the antimicrobial efficiency of the germicides. They are described next.

Nature of the Material

The easiest surface to disinfect is a smooth, nonporous, and cleanable one. If the materials are incompatible with disinfectant, damage and corrosion can occur.

Bioburden

Under a given set of circumstances, the higher the level of microbial contamination, the longer the required exposure to the disinfectant is needed. Additionally, resistant micro-organisms require longer exposure times.

Table 10-4.—Micro-organisms and Levels of Disinfection

Level of Bacterial Activity	Bacterial Spores	Tubercle Bacillus	Nonlipid Viruses	Lipid Viruses	Vegetative Bacteria
High	Maybe	Yes	Yes	Yes	Yes
Intermediate	No	Yes	Yes	Yes	Yes
Low	No	No	No	Yes	Yes
In the absence of gross organic contamination.					

Organic Debris Present

Blood, saliva, and other organic material may contribute to the failure of a germicidal process by either direct inactivation of the disinfectant or the actual layering of the micro-organisms on the instruments or equipment, thereby preventing penetration of the germicide.

Type and Concentration of the Germicide

Generally, when all other variables are constant, the higher concentrations of a chemical agent are more effective and require a shorter time to disinfect. Use of dilutions other than those specified by the manufacturer adversely affect some intermediate-level disinfectants, specifically iodophors. In all instances, follow the manufacturer's recommendations.

GENERAL CATEGORIES OF LIQUID CHEMICAL AGENTS

A large variety of liquid disinfectants are available today, and it is probable that many new ones will become available in the future. When selecting a product, make sure that the label has an EPA registration number on it. Table 10-15, is a guide to chemical agents for disinfection and sterilization. Since they may be subject to change, be sure to read the manufacturer's instructions before using. Next, we will discuss the four most commonly used chemical agents, glutaraldehyde and chlorine dioxide based solutions, iodophors, and phenolics.

Glutaraldehyde-Based Solutions

These agents are available in several formulations differing in pH, concentration, use in dilution, and exposure time. They are classified as high-level disinfectants or sterilants.

Always wear impermeable gloves and protective eyewear when handling these solutions. Irritation of the hands is common and personnel are always at risk of splashes occurring whenever liquids are being

Table 10-5.—Guide to chemical agents for disinfection and sterilization.

Chemical Classifications	Disinfectant [1,2]			Sterilant [1,2]
Products	Dilution	Time	Temperature (20°C = 68°F) (25°C = 77°F)	Dilution, Time, Temperature
Surface or Immersion				
Chlorine compounds				
Alcide LD	10:1:1	3 minutes	20°C	NA[4]
Exspor	4:1:1	3 minutes	20°C	4:1:1, 6 hours, 20°C
Bleach (5.25% sodium hypochlorite)	1:10	10 minutes	20°C	NA
Iodophors				
Biocide Surf-A-Cide	1:213	10 minutes	20°C	NA
ProMedyne–D	1:213	25 minutes	25°C	NA
Combination synthetic phenolics				
Multicide Omni II Vitaphene	1:32	10 minutes	20°C	NA
Immersion				
2% Glutaraldehyde acidic[5]				
Banicide concentrate	1:40	30 minutes	20°C	1:10, 10 hours, 25°C
Banicide Sterall Wavicide	1:4	30 minutes	20°C	Full strength, 10 hours, 25°C
2% Glutaraldehyde neutral[5]				
Glutarex	Full strength	----	----[3]	Full strength, 10 hours, 20°C
2% Glutaraldehyde alkaline[5]				
Cidex activated dialdehyde	Full strength	45 minutes	25°C	Full strength, 10 hours, 25°C
Cidex 7	Full strength	90 minutes	25°C	Full strength, 10 hours, 25°C
Germ-X	Full strength	----	----[3]	Full strength, 10 hours, 20°C
Asepti-Steryl 28 Dentacide Glutall Omnicide Orthcide Sporex Vitacide	Full strength	45 minutes	20°C	Full strength, 10 hours, 20°C
Steril-Ize	Full strength	45 minutes	25°C	Full strength, 10 hours, 20°C
CoeCide XL K-Cide Maxicide Metricide 28 Procicide 14 Procide 30 Protec-top Veratex	Full strength	20 minutes (10 minutes	20°C 25°C)	Full strength, 6 hours, 20°C

1. Always use disinfectant and sterilant products according to the instructions specified on the product label.
2. The conditions listed reflect the time required for tuberculocidal activity for reused solution, if such use is possible, at the minimum temperature and maximal dilution specified on the EPA approved product label. Tuberculocidal test methods may vary. Consult label or manufacturer for specifics.
3. Data not available at time of publication.
4. Not approved for use as sterilants.
5. Alternate conditions, such as increased temperatures or fresh solution as opposed to reused solution, may decrease disinfection time. Consult label instructions for alternate uses.

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handled, so direct physical contact between glutaraldehyde solutions and human tissues should be avoided. When using these agents, they require proper ventilation because their vapors are extremely toxic.

Immersed items must be rinsed with sterile water before using. Glutaraldehydes of 2 to 3.2 percent are FDA-registered. These solutions are not recognized as acceptable surface disinfectants because of the

excessive amounts of exposure time required, corrosiveness, skin sensitization, and odor.

Chlorine Dioxide-Based Solutions

Chlorine dioxide is an effective surface disinfectant or sterilant. These solutions may be used for high-level disinfection of semicritical items that are not subject to corrosion. It has a rapid action of 3 minutes for disinfection or 6 hours for sterilization. As with sodium hypochlorite (bleach), there are several disadvantages: chlorine dioxide must be discarded daily; has a 24-hour use life as a sterilant; and does not readily penetrate organic debris.

It must be used with protective eyewear and gloves because it is extremely irritating to the eyes and skin. It should always be placed in closed containers, and you must ensure adequate ventilation when using for surface disinfection. In addition, it corrodes aluminum containers.

Iodophors

Iodophors are classified as intermediate-level disinfectants or can be used as antiseptics if the product label claims tuberculocidal (lethal to mycobacterium tuberculosis) activity. They are compounds consisting of iodine and usually detergents to which the iodine quickly binds. Iodophor preparations are less irritating to tissues, cause less allergies, and do not normally stain skin or clothing. They should not be used on white or pastel vinyls that are subject to staining from repeated exposure to iodine. Their biocidal activity is accomplished within 10 to 25 minutes of exposure. To ensure tuberculocidal activity, fresh solutions must be prepared daily. As iodophors lose effectiveness, the color changes from amber to clear. Iodophors become somewhat unstable at high temperatures and can have a rapid loss of antimicrobial activity when inactivated by hard water and alcohol. Distilled or at least softened water is recommended to dilute the iodophors before using. Iodophors are EPA-registered and ADA-accepted as surface disinfectants. They may not be used as sterilants.

Iodophor antiseptics are useful in the preparation of oral mucosa for local anesthesia, surgical procedures, and handwashing. Not only does the iodophor remove the microbial populations from the skin, but also a residual antimicrobial effect remains on the scrubbed areas. Although iodophors are used as both antiseptics and disinfectants, the same product is never used for both.

Phenolics

Phenolics are also classified as an intermediate-level disinfectant, provided the product label indicates a claim to tuberculocidal activity. They act as good surface spray cleaners and are effective in the presence of detergents. Phenolics are useful on metal, glass, rubber, and plastic, and are less toxic and corrosive than glutaraldehyde solutions. However, they create a film accumulation, can degrade certain plastics, and etch glass with prolonged exposure. They are very irritating and contact with skin and mucous membranes should be avoided. To prevent skin and eye irritation, protective gloves and eyewear must be worn during their use.

SEMICRITICAL CATEGORY ITEMS REQUIRING CHEMICAL DISINFECTION

Examples of semicritical items requiring chemical disinfection are three-way syringe tips, high-volume evacuator (HVE) and saliva ejector tips, radiographic positioning devices. For the chemical disinfection of semicritical items, use the following procedures:

- Follow the manufacturer's instructions.
- Thoroughly wipe the item with absorbent material saturated with an EPA-registered disinfectant.
- Allow the disinfecting solution to remain in contact with the item for the length of time specified by the manufacturer.
- Whenever possible, all semicritical items that can withstand sterilization should be sterilized.

Although nitrous oxide masks and breathing tubes fall into the semicritical category, if they are autoclavable, clean and sterilize them using steam heat. If not autoclavable, wipe after each use with two separate gauze pads saturated with a high-level disinfectant. If breathing tubes are not autoclavable, after each use, rinse inside and outside with running water, wipe and flush with a high-level disinfectant, and rerinse with water.

Note: All semicritical category items should receive high-level disinfection as shown in table 10-3.

NONCRITICAL CATEGORY ITEMS REQUIRING CHEMICAL DISINFECTION

Examples of noncritical category items requiring chemical disinfection are the following: dental

delivery systems (DDSs), consisting of a chair, unit, and light; portable dental units; surgical table and chair; and X-ray apparatus. For the chemical disinfection of noncritical category items, use the following procedures:

- Disinfect the DDS at least daily.
- Use disposable barriers since they reduce the number of surfaces requiring disinfection.
- Change paper or plastic headrest and bracket tray covers after each patient. If headrest covers are not available, disinfect the headrest after each patient.
- Disinfect hand-operated controls, switches, and handles after each patient.
- Follow the manufacturer's instructions when disinfecting the lamp head and protective shield.
- Flush HVE and saliva ejector tubing and cuspidor weekly with a central evacuation system cleaner. Use more often as needed. Follow the manufacturer's instructions.

Anesthetic cartridges for nonsurgical use should be dispensed under unit dose guidelines to prevent contamination of bulk supplies. Use only individual dose dental carpules and discard them after use. Always follow the manufacturer's instructions. Since disinfectants can diffuse through the diaphragm and contaminate the anesthetic solution, do not store cartridges in these agents.

Note: All noncritical category items require at least intermediate-level disinfection as shown in table 10-4.